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THE REDISCOVERY OF *VEROMESSOR LOBOGNATHUS* (ANDREWS) (HYMENOPTERA: FORMICIDAE)[1]

By Robert E. Gregg

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This species of ant is exceedingly rare, and some conception of its scarcity may be gained from the fact that it was described from four worker specimens taken in 1916 and has been known primarily from these cotypes ever since. The species was collected by Professor T. D. A. Cockerell at Glenwood Springs, Colorado, and the description was drawn up by one of his students, Hazel Andrews. One of the cotypes is in the Wheeler Collection at Harvard and of the remaining three, two only are now present in the Collection of the University of Colorado Museum.

According to Creighton (1950) three specimens were examined by him which supposedly came from Missouri, but he strongly doubts the validity of the record. Recent correspondence, however, with Dr. Creighton and with Dr. W. L. Brown at the Museum of Comparative Zoology, has supplied the following information about the Missouri record. Several specimens of *V. lobognathus* were collected in Barton County, Missouri in May 1920, by J. W. Chapman. At least this is in accordance with the labels on the specimens, but Dr. Chapman denies having been in Barton County at the time indicated. His inability to remember the incident may be due to the long period which has since elapsed. In the Museum of Comparative Zoology there are, at present, two of Dr. Chapman's specimens. Three others are in the collection of Dr. Creighton. One of the specimens in the M. C. Z. collection bears the label "*V. lobognathus* new subsp." and this notation is attributable to Creighton (ca. 1938) who now states that he does not believe that it is a valid new subspecies. The writer concurs in this conclusion, especially because we know so little concerning the distribution and the variability of the typical form of *lobognathus.* Furthermore, the Missouri specimens are smaller than the types and the Colorado sample recently brought to light, and in this and other respects they give the impression of having come from an incipient nest. To base a new subspecies on such material is quite inadvisable.

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[1] Published with a grant from the Museum of Comparative Zoology at Harvard College.

It may seem that the record from Missouri is too far east to be credited with any assurance, especially when even the Colorado records are so far removed from the main range of the genus *Veromessor.* But it is not an impossible occurrence, since Barton County is in the southwestern section of Missouri, on the northern edge of the Ozark Plateau, where tall grass prairie and oak-hickory vegetation interdigitate.

There is the possibility that Chapman's locality may have been a Barton County in another state, and with this in mind, I have searched the maps of the following thirteen states: Iowa, Arkansas, Louisiana, Nebraska, Kansas, Oklahoma, Texas, Colorado, New Mexico, Utah, Arizona, Nevada and California, as any of these states might be included in the range of the species. Of these only Kansas possesses a Barton County and it is situated almost in the geographic center of the state. If Barton County, Kansas, is the correct location for Chapman's specimens, it is more plausible than the Missouri record, but it is still a long way east of Colorado, and for this reason extremely interesting.

The confusion which is detailed in the foregoing paragraphs serves to place in bold relief the dangers attendant upon the attachment of locality labels and the citation of such. The most meticulous care is not too much to exercise in the recording of geographical data and always, it seems to this author, a locality should be given that is more precise than a mere county record. Some counties in western states are larger in area than whole eastern states and, moreover, they frequently encompass tremendous altitudinal changes. Anything less than the nearest large town, mountain peak, large lake, canyon, distance in highway miles, elevation or other means of pinpointing a site on a large scale map is to be deplored and should be accepted only with caution.

In 1953 Creighton suggested that the locality labels of the cotypes of *V. lobognathus* may be incorrect. While this possibility has not been overlooked, I feel that the recent rediscovery of the species in Colorado, even though at a widely separated station, lends credence to Cockerell's Glenwood Springs labels, and we now have little reason for doubting their validity.

On July 22, 1952, thirty-six years after its original discovery, *Veromessor lobognathus* was retaken by me at Owl Canyon, Colorado, approximately twenty miles northwest of Fort Collins. The nest was situated under a rock in pinyon-cedar woodland at an elevation of 6,100 feet. From the colony, 85 workers with brood were obtained, and the ants have been compared with the cotypes of *lobognathus* in the museum and found to be unquestionably conspecific with them. Only insignificant differences between them could be detected. No winged castes were secured.

On casual examination, the specimens look so much like *Pogonomyrmex occidentalis*, that until they were brought back to the laboratory, they were mistaken for that species. However, the reticulate nature of the thoracic and the cephalic sculpture, the spatulate proximal end of the scape, the pronounced saddle-like depression of the meso-epinotal suture, and the broad, sessile postpetiole easily differentiate *V. lobognathus* from *P. occidentalis*. It is the similarity in stature, in pilosity, in color, and the possession of a psammophore in both species that may confuse the unwary. Without magnification, the sculpture of these ants is also astonishingly similar. Wheeler and Creighton

(1934) briefly discuss this close correspondence, and conclude correctly that the resemblance is superficial and due to convergence. The ants are obviously in separate genera. They consider the possibility of mimicry, with *occidentalis* serving as the model. I have exserted the stings of both ants, and while that of *Pogonomyrmex* is much stouter and from appearances more powerful and effective as an organ of defense, it is not possible with the still meagre amount of information we have to say that mimicry is involved. The rarity of *lobognathus*, its distributional characters, and its superficial divergence from other species in its genus do conform to Wallace's Rules for Batesian Mimicry, but it would be premature to label the case as one of mimicry at this time. It may be legitimate to ask whether the weak stings of other myrmicine ants are equally ineffectual for defense, and also what reasons might be deduced to explain why the other members of *Veromessor* which occur in the same habitats as forms of *Pogonomyrmex* more pugnacious than *occidentalis* do not show a defensive convergence towards these latter species?

The distribution of *V. lobognathus* is distinctly unorthodox, almost all the rest of the species in the genus being confined to the southwestern deserts of Arizona, California (including the Central Valley), Lower California, and western Mexico. A gap of several hundred miles exists between the previously known records of *Veromessor* and Glenwood Springs, the type locality of *lobognathus*. Several years ago, Dr. M. R. Smith (1951) described a new form of this group, *V. lariversi*, which had been secured near Pyramid Lake, Nevada, and since then Dr. Creighton has found the species near Lone Pine, California, Wagner, Nevada, and Goldfield, Nevada. Thus the genus is now known to extend further east in the northern part of its range than heretofore. But this extension makes no significant change in the status of *lobognathus* whose most western station is in the upper reaches of the Colorado River Canyon at an altitude of 5,750 feet (Glenwood Springs), with its most recent occurence now recorded from the eastern slope of the Rocky Mountains at an elevation of 6,100 feet. From the nature of the genus and the species which compose it, it may be taken as certain that a distributional gap exists between these two sites, as far as *V. lobognathus* is concerned, which is imposed by the lofty heights of the continental divide. It seems extremely improbable that future collecting will demonstrate a pattern of dispersal around the southern end of the Rockies, for if such existed, the species should find itself in a much more congenial environment in the south and should have turned up as a fairly common ant in collections from such areas. The possibility of a connection across a low pass during a remote period cannot as yet be ruled out, however.

In her description of *lobognathus*, Miss Andrews includes no mention of the habitat in which the ants were found. I have found no additional ecological information upon examining the original hand-written notes. In the writer's experience, the hills and canyon walls near Glenwood Springs are covered with scrub oaks, and the river bottom, where wide enough, has meadows with some willow and cottonwood. A small amount of pinyon and cedar is also known to be present. It is not known whether the types were obtained from natural vegetation or the altered conditions in the town. The specimens collected at Owl Canyon were definitely living under natural conditions in a stand of pinyon and cedar. This is an isolated woodland (though some of the pinyons are extremely old and very large for the species), whose nearest approach of similar vegetation containing pinyons is about 160 miles south near Colorado Springs, in the Garden of the Gods. The stand is, moreover, surrounded by plains vegetation of grassland and sagebrush, and by mountain mahogany which is a foothills plant. Varying explanations have been suggested to account for the presence of these conifers near Owl Canyon in view of the fact that pinyon, while occurring far north on the west side of the divide, stops at Colorado Springs on the east. It would appear that the most plausible diagnosis is the one offered by some botanists to the effect that we are confronted with a relict stand. If this is true, the known distribution of *V. lobognathus* coincides quite well with it, for its pattern looks like that of a relict species — rare, patchy in distribution, disconnected with its relatives, and correlated with a similar distribution of other taxonomically unrelated organisms. The cause of such a relict distribution in this case is not immediately evident, and it seems best not to speculate on this phase of the problem. On the other hand, the Owl Canyon pinyons may not be true relicts of a former more widespread vegetation type on the east slope because none of the herbaceous flora commonly associated with pinyons is present[2]. Also, one difficulty with a relict interpretation of the Glenwood Springs record of *lobognathus*, is that while pinyon does grow in the area, it is in no way a relict stand.

Control of distribution by a soil factor deserves consideration. Both the Owl Canyon site and the Glenwood Springs area have limestone outcroppings. Surface exposures of this rock are not abundant in Colorado, and some plants seem to show a correlation with those that do exist. Whether we can extend this reasoning to ants, and the particuar case in question, is highly uncertain. In general, ants do not show the correlations with the chemical constitution of the soil that is so often true of plants. Their protoplasm is relatively protected and insulated from direct soil contact as opposed to the roots of plants. Some soil-ant relationships have been observed, however, but in such cases the effect on the ants seems to be that of the physical nature (texture) of the soil particles.

It is hoped that when the localities where *V. lobognathus* occurs are revisited, it will be possible to find the species again and study the behavior of this singular ant. At least it will be easier in the future to detect its presence in a habitat, and this may lead to the discovery of additional records. Until then, the distribution of this insect remains very problematical.

Specimens of the ant have been deposited in the collections of W. S. Creighton, the United States National Museum, and the Museum of Comparative Zoology.

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[2] Information was secured from Dr. William A. Weber.

POSTSCRIPT

Since this paper first went to press, some important new data have come to light. Dr. Dallas Sutton, while collecting a few ants for me, obtained specimens of *V. lobognathus* in pinyon-cedar woodland with sagebrush, at 6,500 feet, twenty miles southwest of Rangely, Colorado, on August 26, 1952. As he was unaware of the nature of his find, no other data are available. An additional record also has been kindly reported in correspondence by Dr. A. C. Cole. The ants were secured during the summer of 1954 at a point forty-five miles west of Ely, Nevada, in sagebrush desert, and according to Dr. Cole, occupied a small pebble mound nest.

These two records are extremely valuable not only because they extend the known distribution of *lobognathus* hundreds of miles beyond its previous boundaries, but serve to establish possible connections with other members of the genus, notably *V. lariversi* in eastern California and western Nevada. Thus the most western station for *lobognathus* is now in eastern Nevada (near Ely), and it is not observed again until the localities in northwestern, western, and northern Colorado are reached. Finally, it reappears in southwestern Missouri. Wherever else the species may be discovered, it seems safe to predict that it should exist in some parts of Utah and of Kansas, but such a pattern if filled out would not correlate with any major natural features of the continent, such as mountains, desert basins, or prairies. Rather, it would cut across these features. The species may prove eventually to have a wide but very local and patchy type of distribution, the elucidation of which will require extensive search and many more records.

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THE ANT CERAPACHYS RUFITHORAX AND ITS SYNONYMS — Dr. J. W. Chapman has given me a series of *Cerapachys* taken as a uninidal lot in the Cuernos Mountains, near Dumaguete, Negros Or., Philippine Islands, and has kindly called my attention to the remarkable variation in size and form shown by its members. This variation is clearly allometric, and affects most importantly the profile of the alitrunk and thickness of the petiole and postpetiole. *C. rufithorax*, *C. negrosensis* and *C. nitida*, all described from the Cuernos Mts. (450-700 M. altitude) by Wheeler and Chapman (types in Museum of Comparative Zoology) were found to correspond to different segments of the uninidal sample as arranged according to size, so that it is evident that the three names represent size-classes of a single species. Formal synonymy follows.

Cerapachys rufithorax Wheeler and Chapman

Cerapachys rufithorax Wheeler and Chapman, 1925, Philippine Jour. Sci., 28: 50, pl. 1, figs. 5, 6, 7, worker.

Cerapachys negrosensis Wheeler and Chapman, 1925, ibid., p. 51, pl. 1, fig. 8, worker. **New synonymy.**

Cerapachys nitida Wheeler and Chapman, 1925, idem, p. 52, pl. 1, figs. 9, 10, worker. **New synonymy.**

Size differences with allometry serve as specific differences to separate other Cerapachyinae, so that we may expect further synonymic reduction as adequate series become available. — William L. Brown, Jr., Museum of Comparative Zoology.

FURTHER NOTES ON THE HABITS OF *GEOTRUPES* (COLEOPTERA: GEOTRUPIDAE)

BY F. N. YOUNG[1], T. H. HUBBELL[2], and D. W. HAYNE[2]

A previous note (Psyche, 57 (3): 88-92) records observations on the habits and habitat of *"Geotrupes chalybaeus"* from an atypical scrub area near Interlachen, Putnam County, Florida. Dr. Henry F. Howden informs us that these notes apply to an undescribed species. The following observations made in early March, 1935, apparently apply to *Geotrupes* (*Peltotrupes*) *profundus* Howden (= *chalybaeus* LeConte, not Mulsant.)

Thirteen holes, thought to be mouse burrows, were excavated in the turkey-oak high-pine area (*Quercus laevis-Pinus palustris* associes) west of Lake Newnan, Alachua County, Florida. The soil in this area is largely Lakeland sand ("Norfolk sand") or similar dry sands, which usually have a white or very light surface layer and yellowish sand beneath. Such sands are somewhat more compact and have a denser layer of tree roots closer to the surface than the St. Lucie sand in which burrows were excavated near Interlachen. Here, as elsewhere, the "throwups" or mounds were largely in groups.

Burrows were traced by inserting a wire in the hole beneath the "throwup", and digging along it with a trowel. Some burrows could be traced by a blackened ring around the inside, apparently due to deposits of organic substances from material carried down by the beetles. The depth to the apparent bottom of the burrows varied from 10″ to 66″, but no beetles were found in any not excavated below 48″. The diameter of the burrows was rather constant at about ½″. Several of the burrows did not descend straight down as was usually the case near Interlachen, but deviated at various angles and then straightened again at various depths. A short lateral burrow beneath the mound was observed in three cases. It is possible that some of the shallow burrows excavated were in the process of being dug by the beetles or had been abandoned.

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[1] Department of Zoology, Indiana University

[2] Department of Zoology, University of Michigan

Material found in underground chambers connected with the burrows or in the burrows themselves was largely the surface "duff" of the turkey oak woods. Acorn cups, grass, live oak leaves (partly eaten?), leaf debris, pine needles, bark, and twigs were encountered along with some insect fragments. One burrow ended at 66″ in a horizontal chamber about 6″ long and 1½″ wide. This chamber was filled with leaf debris, cut-up grass, and other material. Another ended at 48″ in a chamber about the size of a golf-ball and completely filled with dry sand.

In the burrow which ended in a chamber at 66″ two beetles were found: one in the burrow at 48″ and another in the chamber. The latter was apparently in a death-feint, but recovered the next morning, and was observed to make a rasping sound, probably with the hind coxae and the 1st abdominal segment as in other *Geotrupes*. A similar sound was heard while one burrow was being excavated, but was mistaken for a mouse "clicking" its teeth.

The stridulation (presumably of the male) which does not seem to have been previously noted, together with the discovery of two beetles (probably the male and female) in the same burrow, strengthens the supposition that these beetles show some sort of subsocial activity.

INTRA-UTERINE NUTRITION OF THE "BEETLE-ROACH" *DIPLOPTERA DYTISCOIDES* (SERV.)[1] DURING EMBRYOGENESIS, WITH NOTES ON ITS BIOLOGY IN THE LABORATORY (BLATTARIA: DIPLOPTERIDAE)

By Louis M. Roth and Edwin R. Willis
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Natick, Massachusetts

Diploptera dytiscoides is a common viviparous cockroach that injures the bark of several kinds of trees in Hawaii and other Pacific Islands (Fullaway and Krauss, 1945). Its embryology has been extensively studied by Hagan (1951) who indicated that the embryo increases over five times in size during development. This growth was not accompanied by a decrease in yolk, and Hagan suggested that the developing embryo acquired nutriment from another source. The embryos have greatly elongated pleuropodia to which Hagan (1939, 1951) tentatively ascribed nutritional or respiratory functions, or both. Because of the embryo's increase in size and its modified pleuropodia, Hagan (1951) cited *D. dytiscoides* as the one example of pseudoplacental viviparity among cockroaches. Although Hagan's suggestion is a logical hypothesis, the acquisition of nutriment by the embryo has never been examined experimentally.

The eggs of the false ovoviviparous cockroach, *Nauphoeta cinerea* (Oliv.), also increase in size during embryogenesis; this increase is closely correlated with absorption of water, whereas solids are slowly lost until hatching (Roth and Willis, 1955). In order to determine whether absorption of water alone could account for the increase in the size of *Diploptera* eggs, we have studied the changes, with age, in wet weight and in dry matter and water content of the developing eggs.

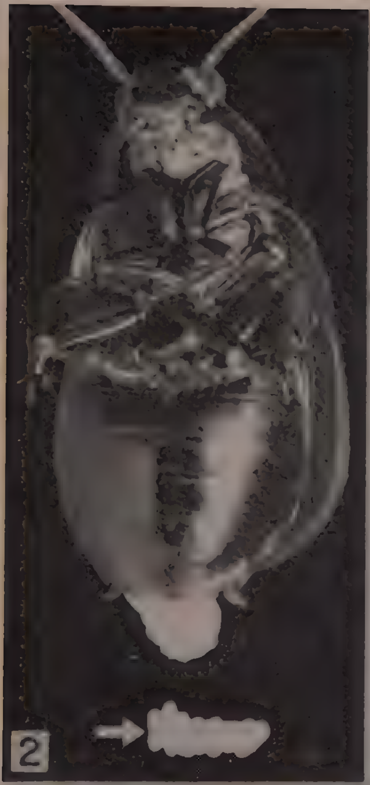
---

[1] We are greatly indebted to the United States Department of Agriculture for permission to import this species, and to Mr. Fred A. Bianchi of the Hawaiian Sugar Planters Association, who kindly sent us several hundred living specimens of *Diploptera*. The insects were cultured on Purina dog chow checkers.

Female *Diploptera* were removed from the cultures, anesthetized with CO_2, and their oöthecae were expelled by finger pressure against the base of the abdomen. Because oötheca formation was rarely observed, the exact age of the eggs was unknown. Therefore, the length of an end egg in each oötheca was measured with an ocular micrometer and its size was used in lieu of age. All weights were determined on torsion balances sensitive to 0.01 and 0.05 mg. Oöthecae were air-oven dried at about 100°C. to constant weight. All determinations were made on eggs enclosed in oöthecae (rather than on individual eggs), but calculations are presented on a per egg basis. The oötheca itself (fig. 5, arrow) is so reduced in this species that its inclusion in the calculations is a negligible factor, particularly with older eggs which have greatly increased in size. Sometimes an oötheca contained one or two eggs which failed to develop; these were easily removed without damage to the remaining eggs and were not included in the weight determinations. The usual number of eggs in an oötheca is 12 (Hagan, 1941); of 51 oöthecae examined by us, the number of eggs ranged from 9 to 13 (including undeveloped eggs), with a mean of 11.4 per oötheca. Hagan (1954) thinks that this average may be due to altered environment, food, and captivity. In Hawaii he seldom found less than 12 eggs per oötheca and usually more than that number, although he did not record the data.

EXPLANATION OF PLATE 4

Figures 2-4. *Diploptera dytiscoides*. Fig. 2. Female with an everted uterus (as a result of once having had her abdomen squeezed to remove an oötheca) and a recently formed oötheca (arrow) which she extruded because it could not be retracted into the brood sac (×3.8). Fig. 3. Female, after accidentally being exposed to high temperatures, prematurely aborting an oötheca containing well-developed embryos (×3.8). Fig. 4. End view of abdomen of female; genital segments separated to show 4 embryos visible in the brood sac. Note eye (arrow) of embryo (×7.5).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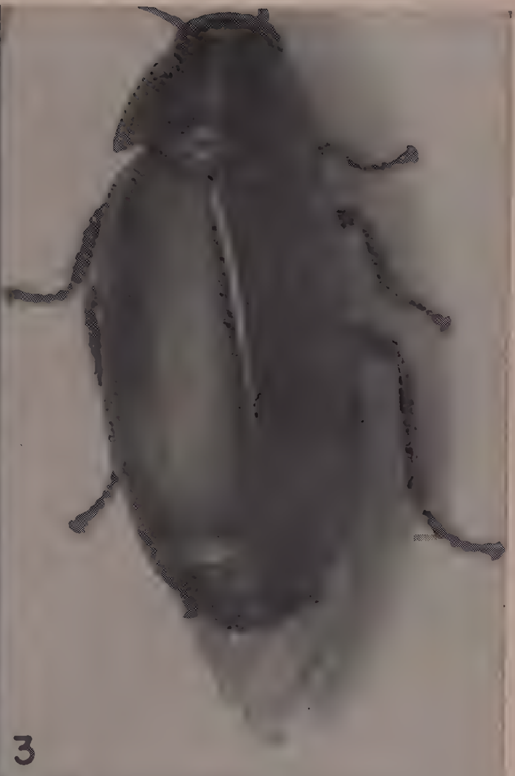
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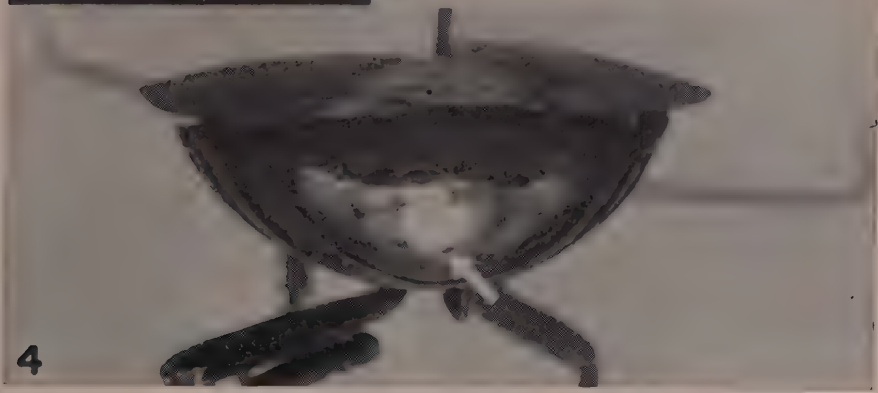
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ROTH AND WILLIS — DIPLOPTERA DYTISCOIDES

Evidence for Intra-uterine Nutrition

The weight, water, and dry matter changes which accompanied the increase in egg size are shown in figure 1; a series of oöthecae containing eggs of different sizes are shown in figures 5-9. The smallest eggs (0.93 mm.) undoubtedly were from a very recently formed oötheca. Hagan (1951) stated that the freshly deposited egg is approximately 1.20 mm. long. The largest eggs (6.9 mm.) represent fully matured embryos, inasmuch as some of the eggs in this oötheca began to hatch shortly after they were manually extruded from the female (figs. 9-13). The difference in size between the smallest and largest eggs represents more than a seven-fold increase during embryogenesis. The size and weight of the eggs increase with acquisition of both water and solids. However, most of the weight increase arises from absorption of water. From the smallest to the largest eggs there was an increase of about 50 times in the amount of dry matter and about 85 times in water content. Visible differentiation was accompanied by the first observed increase in dry matter (fig. 1, arrow). Prior to differentiation the eggs absorbed water only, and the dry matter content dropped from about 34% to about 26%. After differentiation became visible, the dry matter content remained at approximately 26% throughout development. The increase in the size of the egg, as Hagan (1951) pointed out, cannot arise from the small amount of yolk available, nor could the increase in dry weight be interpreted on this basis. Obviously, additional nutriment is supplied by the mother to the eggs in the brood sac. The exact source of this nutriment is not known; Hagan (1941) suggested that nutriment may be secreted by the maternal accessory (colleterial) glands.

Diploptera is unique among cockroaches in gaining solid matter from the mother during embryonic development. In oviparous cockroaches (*Blatta orientalis* L., *Blattella vaga* Heb., *Blattella germanica* (L.)) and false ovoviviparous species (*Nauphoeta cinerea*, *Pycnoscelus surinamensis* (L.), and *Leucophaea maderae* (F.)) solid matter is lost during embryogenesis, although water is absorbed from the oötheca or directly from the mother (Roth and

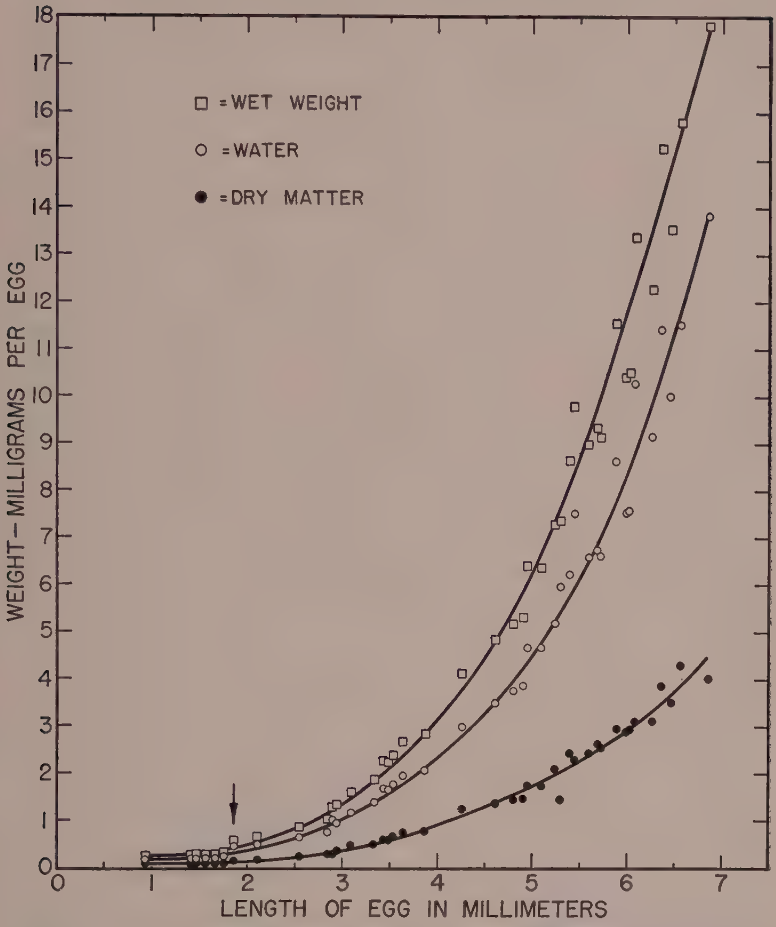


Figure 1. Wet weight, water, and dry matter changes of the eggs of *Diploptera dytiscoides* with increasing age (as indicated by increase in size). All determinations were made on oöthecae containing 9 to 13 eggs, but the data are plotted on a per-eggs basis and include the weights of the oöthecae. Arrow indicates first sign of visible differentiation of the embryo.

Willis, 1955). The gain or loss in water or solids by the eggs of various cockroaches during embryogenesis is compared in table 1. Only the egg of *Diploptera* changes greatly with a truly tremendous gain in water and solids.

And yet, morphologically, the reproductive system of *Diploptera* is comparable to that of *Blatta orientalis*, although some of the structures in *Diploptera* have become modified with its altered physiology (Hagan, 1941).

TABLE 1

Changes in wet weight, water, and solids of the eggs of several species of cockroaches during embryogenesis[1]

Species	Factors by which initial weights changed, per egg[2]		
	Wet weight	*Water*	*Solids*
Blatta orientalis[3]	1.21	1.35	0.96
Blattella vaga	1.12	1.32	0.81
Blattella germanica	1.21	1.49	0.74
Nauphoeta cinerea	2.11	4.62	0.81
Diploptera dytiscoides	73.47	85.80	49.28

Of all the viviparous cockroaches, *Diploptera* is the most highly evolved: the oöthecal covering is reduced, and the small size and number of eggs and the comparatively large size of the vestibule apparently make it possible for the female to transfer the oötheca into her brood sac without exposing the majority of eggs outside her body. Strictly speaking, *Diploptera* may be the only known case of true viviparity among cockroaches, in that the eggs are apparently rarely extruded beyond the vestibule and the embryos derive nourishment (other than yolk or water) from the female.

BIOLOGICAL OBSERVATIONS

We have frequently observed courtship and copulation.

---

[1] The data for species other than *Diploptera* were computed from Roth and Willis (1955).

[2] Except for *B. orientalis* (see footnote 3), the weights of the oöthecae were included in the computations, and therefore the actual changes would be somewhat larger; the youngest eggs had been recently deposited and the oldest were about ready to hatch. Factors less than unity indicate a decrease in weight.

[3] Based on eggs removed from the oötheca; the youngest eggs were 11 days old and the oldest 32 days old (about 1 week prior to hatching), so that the changes might have been somewhat higher if recently laid and fully developed eggs had been used.

The active male follows the female and palpates her body or genital region. He then partly raises and flutters his wings, turns his terminal abdominal segments toward the female, pushes backward under her and grasps her genitalia. Once they are hooked together, the male swings around into the typical opposed position with his head 180° from the female's. Newly emerged, teneral females are very attractive to, and are courted by, older males; 2 males were attracted to a female that was only partly out of its last nymphal skin and went through weak courting movements. Surprisingly, these young females mate normally (fig. 14) and in laboratory cultures the mating of teneral females is a common occurrence. According to Hagan (1951, p. 320), sexual maturity in *Diploptera* ". . . follows physical maturity rather promptly, if the presence of well developed follicles in the last nymphal instar is any criterion." Teneral females have been seen in copula before their wings had become fully extended; examination of one such female, after she had been in copula for more than an hour and had separated from the male, showed that she had received a spermatophore (fig. 15). Another teneral female, isolated while still in copula, separated from the male about 30 minutes after isolation. Sixty-seven days later, she give birth to 13 nymphs; temperature and humidity were uncontrolled during the gestation period.

We have observed four females forming oöthecae. When the first female was seen, her terminal abdominal segments were slightly separated. We anesthetized the insect and, upon microscopic examination, found about 6 eggs aligned vertically in a double row in her vestibule. After the female had recovered, she began pulsating movements, expanding and telescoping the end segments of her abdomen. While viewing the posterior end of the female during these movements, we could see the first egg through a hand lens. None of the eggs protruded completely beyond her body. About three hours after the female ceased her ovipositing motions, she was dissected. The oötheca, containing 10 eggs, had rotated (micropyles to the left) and it lay partly in the vestibule and partly in the brood sac.

The other three females were discovered in the stock colony by Dr. Barbara Stay of our laboratory. Two of these were observed expanding the end of the abdomen. Although the oöthecae did not protrude beyond the ends of the abdomens, the distal ends of the oöthecae could easily be seen in profile as the females separated their genital segments. The axes of the eggs were vertical at this time. These oöthecae were rotated a short time later, cephalic ends of the eggs to the females' left, and retracted into the brood sac. The females were then dissected; the oöthecae contained 11 and 10 eggs, respectively.

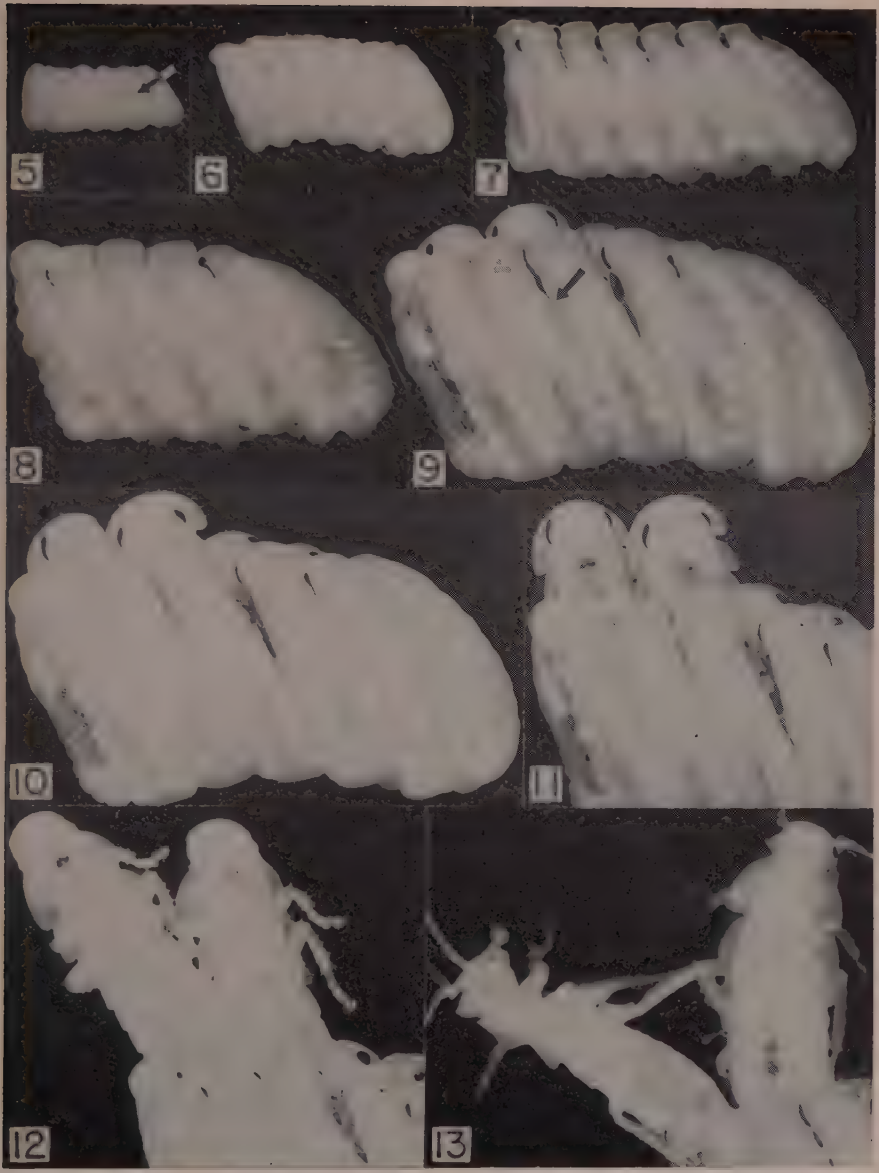
The fourth female was seen with the first egg and parts of the succeeding two eggs protruding beyond the end of her abdomen. The axes of the eggs were vertical, but within a few minutes the female rotated the oötheca, as above, and retracted it. This oötheca was later found to contain 13 eggs and the female's right ovary had seven and the left six ovarioles. These observations show that our a priori hypothesis of oöthecal formation in *Diploptera* (Roth & Willis, 1954) is correct, being similar to that found in other cockroaches.

Protrusion of eggs beyond the end of the abdomen during oöthecal formation apparently depends on such factors as size and number of eggs and size of the female. From our observations, it seems likely that few eggs protrude beyond the female's body and that protrusion occurs rather infrequently.

Since writing the above we have seen oviposition several more times; ovipositing females were recognized when they repeatedly expanded and contracted their genital segments. The first laid egg was visible for only a short time from behind or from the side. Rotation and retraction of the oötheca occurred rapidly, in a matter of minutes.

EXPLANATION OF PLATE 5

Figures 5-13. Eggs of *Diploptera dytiscoides* (×5). Figs. 5-9. Eggs of various ages showing increase in size. Actual lengths of the eggs as follows: fig. 5. 1.7 mm. (note lack of visible differentiation; upper limit of thin oöthecal membrane indicated by arrow); fig. 6. 3.1 mm.; fig. 7. 4.3 mm.; fig. 8. 5.7 mm.; fig. 9. 6.9 mm. (arrow indicates a strand of greatly stretched, perforated oöthecal membrane). Figs. 10-13. Sequence showing hatching of 2 eggs from oötheca shown in figure 9; hatching occurred within 3-minute period.



ROTH AND WILLIS — DIPLOPTERA DYTISCOIDES

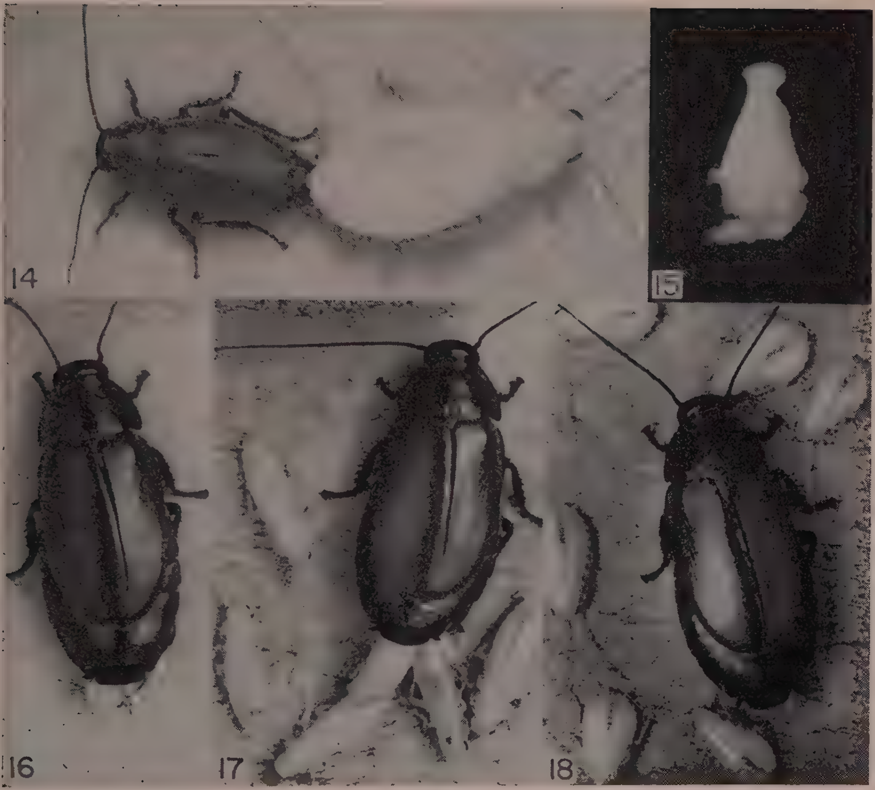
The rapidity of the ovipositional sequence explains why oviposition had not been seen previously in *Diploptera.*

In only one instance did we see a newly formed oötheca completely extruded by a female. We had previously removed an oötheca from this female by finger pressure against her abdomen; apparently this manipulation had damaged her reproductive organs and she was unable to direct the subsequently formed oötheca into her brood sac (fig. 2). A similar abnormality has been observed in *Nauphoeta cinerea* (Roth and Willis, 1955). Females of *Diploptera* that were accidentally exposed to temperatures above 100°F. were seen to abort oöthecae containing apparently dead eggs in various stages of development (fig. 3); this effect of high temperature has been observed in *Pycnoscelus surinamensis* by Roeser (1940).

Kotinsky (1909) found a female of *Diploptera dytiscoides* which, upon being captured, dropped a "batch of embryos" which had been projecting from her abdomen; he concluded from this that the species is viviparous. In *Diploptera,* the fully developed eggs lie diagonally in the brood sac with their cephalic ends pointed posterio-laterally. The head of the full-grown embryo nearest the genital opening of the female may protrude slightly from the brood sac; if the female's genital segments are spread apart, the embryo's head may be readily seen (fig. 4). We have observed hatching of *Diploptera* several times. The abdomens of females carrying fully developed embryos become so distended that the intersegmental membranes between the abdominal sternites are visible. The mature embryos are extruded head first (figs. 16-18). They appear by pairs, swallowing air, the heads of successive pairs

Explanation of Plate 6

Figures 14-18. *Diploptera dytiscoides.* Fig. 14. Older, dark-colored male in copula with a recently emerged, teneral female. Fig. 15. Spermatophore (narrow region is the anterior part) removed from a mated teneral female. Figs. 16-18. Female giving birth; time interval between figures 16 and 17 was 9 minutes; that between 17 and 18 was 22 minutes. This female gave birth to only 6 individuals; the others of the brood failed to emerge from the uterus. (Figure 15 about ×13; all other figures about twice natural size.)



ROTH AND WILLIS — DIPLOPTERA DYTISCOIDES

appearing before the preceding pair has completely freed themselves from their embryonic membranes. The embryonic membranes slip back toward the nymphs' caudal segments while they are still held by the genital segments of the female. When the nymphs drop from the mother and move off, the membranes are left behind attached to the vestigial oötheca in the posterior part of the female's genital cavity. The oötheca and embryonic membranes adhere to the female until all the eggs hatch, after which the female expels them, if necessary, with the aid of her hind legs. Thus, the birth product of *Diploptera* is an embryo devoid of a chorion, oötheca, and even the embryonic membrane. This type of birth is characteristic of truly viviparous insects (Hagan, 1951). In *Nauphoeta* and a number of other so-called ovoviviparous species the final birth product is frequently, if not always, the oötheca containing fully matured embryos which begin to hatch after the oötheca has passed beyond the caudal extremity of the female (Roth and Willis, 1954). We have found the pleuropodia of the embryos left behind with the oötheca and embryonic membranes; apparently the pleuropodia are severed from the body at or before hatching time.

We (1954) have questioned whether the so-called ovoviviparous cockroaches are truly viviparous because their oöthecae are first extruded externally during formation and then retracted into the brood sac. Hagan (1954) suggests that the extrusion and retraction of the oötheca into a brood sac represents ". . . a special case of maternal care of the oötheca and its ova." Some oviparous Homoptera place their eggs in a fold in the hypodermis, a location foreign to the reproductive system, until they hatch (Hagan, 1953). The extrusion and retraction of the eggs of the so-called ovoviviparous cockroaches is comparable to the homopteran behavior, with the exception that the oviposition site is a brood sac within the reproductive system.

When the new-born nymphs of *Diploptera* eliminate the air which distends their bodies (fig. 18), they may eat the embryonic membranes and sometimes the oötheca as well. These first instar nymphs are unduly large in comparison with the nymphs of other species of cockroaches, even those with adults twice the size of the adult *Diploptera.*

Mr. George Riser, formerly of our laboratory, working on the life history of *Diploptera,* has found that at 85°F. eggs hatch about 58 days after the female has mated; allowing about a week after copulation for oöthecal formation, embryogenesis takes about 50 days. He also found that nymphal development took about 38 days for males (9 individuals) which molted only 3 times; females (13 individuals) took about 50 days to mature and underwent 4 molts. Molted skins are not eaten by nymphs or adults.

We thank Dr. Harold Hagan for his interest and for critically reading the manuscript.

SUMMARY

The eggs of the viviparous cockroach *Diploptera dytiscoides* absorb both water and solid matter from the female. During embryogenesis, dry matter in the eggs may increase about 50 times and the water content may increase about 85 times. In its embryonic development, *Diploptera* is unique among cockroaches in that the embryo gains solids from the mother in addition to the yolk initially present in the egg.

In laboratory colonies, teneral females mate normally with older males. The oötheca is formed as in other species of cockroaches: the eggs are extruded from the oviduct and arranged vertically in an oötheca within the vestibule. Sometimes one egg (the first laid) may protrude beyond the end of the abdomen, but most of the eggs remain within the vestibule while the female rotates the oötheca and starts retracting it into her brood sac.

The number of eggs per oötheca ranged from 9 to 13, with a mean of 11.4. Embryogenesis takes 50 or more days. The embryos hatch in pairs, being extruded head first from the female. Male nymphs took about 38 days to mature, molting 3 times; females became adults after about 50 days, molting 4 times.

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REDESCRIPTION OF *SPILOCONIS PICTICORNIS* BANKS (NEUROPTERA: CONIOPTERYGIDAE)[1]

By F. M. Carpenter
Harvard University

Within the past two years several lots of specimens of *Spiloconis picticornis* Banks have been sent to me from the Department of Biological Control at the Citrus Experiment Station, California. Some of these were secured on Hong Kong, China, by Dr. S. Flanders; but most of them were reared at the Citrus Experiment Station from stock obtained on Hong Kong. This extensive series of specimens has made possible the preparation of a more detailed description of the species than could be achieved from the unique female type on which the species was originally based.

I am indebted to M. E. Badgley, C. A. Fleschner, and J. C. Hall, all of the Citrus Experiment Station, for providing me with specimens used in this study. An account of the biology of *picticornis* by these investigators follows in the present issue of Psyche; it is a significant account, since little is known about the biology of the coniopterygids in general and nothing at all has previously been known about the life history of any species of *Spiloconis*.

The genus *Spiloconis* was erected by Enderlein in 1907, within the subfamily Aleuropteryginae, to include two species. One of these, *sexguttata* Enderlein (genotype), was known only from Japan, though Enderlein later (1908) recorded it from Formosa as well; the other was *maculata* Enderlein, from New South Wales, originally described (1906) in *Helicoconis*. A third species, *interrupta*, was described from Mindanao (Philippines) by Banks, in 1937. A fourth species, *picticornis*, was described from Hainan, by the same author, in 1939. Finally, Banks (1939) transferred to *Spiloconis* Hagen's *cerata* from Ceylon, originally assigned to *Coniopteryx*.[2] Up to the present time, therefore, the genus has been known from Australia and five islands in the Asiatic region. The specimens of *picticornis* from Hong Kong are the first of the genus recorded from the Asiatic continent.

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[1] Published with a grant from the Museum of Comparative Zoology at Harvard College.

The outstanding characteristic assigned to *Spiloconis* by Enderlein is the unusual length of the first two antennal segments, both of which are several times as long as wide; in other genera of the family these segments are about as broad as long. Knowing only *sexguttata* and *maculata* at the time of the description of *Spiloconis*, Enderlein was led to believe that the genus might also be characterized by maculations on the fore wings, but *picticornis*, *interrupta* and apparently *cerata* have unmarked wings. In all probability the most significant generic features will be found in the terminal abdominal segments of both sexes. An account of these terminal structures in *picticornis* is given in detail below, but until equivalent structures are known in other species, we cannot propose their generic application.

The redescription of *picticornis* included below is based in part on the type, which is in the Museum of Comparative Zoology, but largely on eighty-five additional specimens, as follows: 3 ♂, 3 ♀, Taipo, Hong Kong, China, Jan. 1, 1954, ex citrus (Flanders); 2 ♂, 1 ♀, Fanling, Hong Kong, Nov. 16 and 25, 1953 (Flanders); 23 ♂, 19 ♀, bred from Hong Kong stock at Riverside, California, Dec. 20, 1954; 20 ♂, 10 ♀, same, May 7, 1954; 4 ♂, 3 ♀, same, April 17, 1955. All of this material is preserved in alcohol and is deposited in the Museum of Comparative Zoology.

The fore wing of the type is 2.3 mm. long and 1 m. wide (maximum); in other specimens which I have examined it ranges from 2.5 to 1.9 mm. long, and from 1.1 to .8 mm. wide. The general body color of living or alcoholic specimens is pale yellow; that of dried specimens is much darker. The frons is light yellow, occipital and genal areas brown. The antennae in all specimens which I have seen,

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[2] *Spiloconis rufa* Nakahara, originally described from Japan in 1913, is now considered by its author to be a synonym of *sexguttata* (*in litt.*).

including the type[3], consist of 18 segments; the scape is about six times as long as any segment of the flagellum, and the pedicel is about four times as long. The proximal eight segments are light yellow, though the 8th is sometimes partially gray; the next two (9th and 10th) are either black or dark gray; the next two (11th and 12th) light yellow; and the distal six (13th through 18th) black or nearly so. This pattern of coloration is uniform in all specimens which I have seen, though the intensity of pigmentation in segments 9 and 10 varies somewhat. The maxillary and labial palps are black or nearly so on the outer surfaces, but lighter on the inner. The thorax and abdomen are pale yellow, except for the dark brown lines which mark the apodemes; the legs are pale yellow, but with some light tint of gray on the femora. The wings are smoky brown and lack maculations; certain cross-veins and parts of some main veins are obsolescent, their positions being indicated by white streaks in the wings. The venation, shown in figure 6, is typical of that of the Aleuropteryginae; I have seen no obvious variations in the venational pattern of either wing. The pattern is like that of *sexguttata*, except that the bases of the macrotrichia are more conspicuous and are proximal to the middle of the wing.

The terminal abdominal segments of *picticornis* differ greatly from those of the species of the Coniopteryginae and Aleuropteryx. Since I have had no opportunity to make a comparative study of the terminalia of other species of *Spiloconis*, I am unable to indicate which characteristics are generic and which are specific. The most striking peculiarity of the male abdomen is the reduction of the ninth tergite and sternite. Although the sclerotization of the abdomen is weak, the first eight segments are readily distinguished, each bearing a pair of spiracles; segments 3-6 also have the evaginable sacs peculiar to the Aleuropteryginae. The tenth tergite is distinct but the ninth appears to be fused with the eighth, presumably bearing the distal row of macrotrichia. The anus is clearly seen just above the strap-shaped tenth sternite, which forms the roof of the genital opening; at the base of the tenth sternite is a complicated supporting structure into which the parameeres and aedeagus extend; this supporting structure is apparently the gonarcus, described in the Coniopteryginae by Tjeder[4]. The parameeres are fused together to form a cylindrical body, with a terminal and a subterminal hook distally (possibly the aedeagus) and a pair of divergent arm-like processes dorsally. The gonarcus and parameeres showed no obvious variations in the fifteen specimens of *picticornis* which I dissected. The parameeres are apparently not attached to the gonarcus, but the distal end of the fused parameeres extend into the gonarcus a short distance; in figure 2 the parameeres are shown slightly removed from their normal position in the gonarcus. The triangular and curved tips of the gonarcus project slightly from the genital opening and can readily be seen when the abdomen is observed from the side (figure 1). There is no indication of a ninth sternite or of the hypandrium, which is well developed in the Coniopteryginae. The floor of the genital opening consists of the eighth sternite; this is directly ventral to the corresponding tergite.

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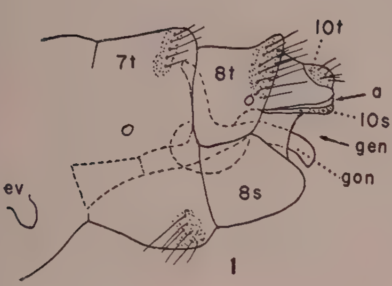
[3] Banks' statement that there are 20 antennal segments in the type was apparently an error. His description of the color pattern was also incorrect, probably as a result of his mistake in counting the segments.

In the female, the ninth abdominal tergite is apparently fused with the eighth; between the eighth tergite, which bears spiracles, and the anus, there is only a single

[4] It is probably a derivative of the tenth sternite (Killington, 1936).

EXPLANATION OF PLATE 7

Spiloconis picticornis Banks. Fig. 1. Terminal abdominal segments of male, drawn from reared specimens (lateral view); 7t, 8t, 9t, 10t, tergites; 8s, 10s, sternites; a, anus; gen, genital opening; gon, gonarcus; ev, evaginable sac. The parameeres and internal portions of the gonarcus are shown by dotted lines. Fig. 2. Gonarcus (top) and parameeres (bottom), dorsal view. Fig. 3. Terminal abdominal segments of female, drawn from type (lateral view); gph, gonapophysis; other lettering as in figure 1. Fig. 4. Gonapophysis of ninth segment of female, drawn from reared specimens (ventral view). Fig. 5. Venation of fore and hind wings; the dotted lines indicate obsolescent parts of veins.



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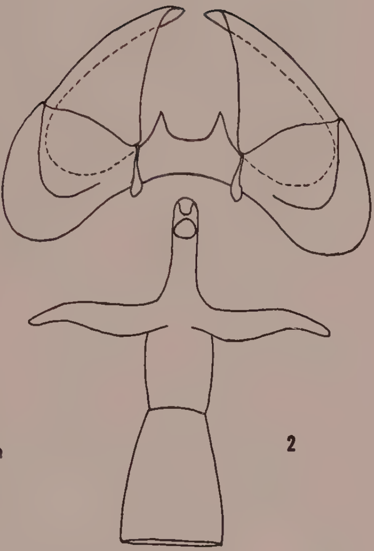

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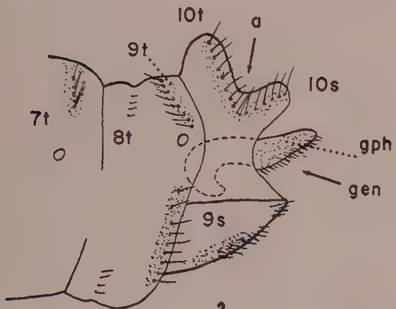

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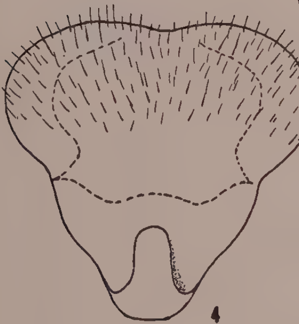

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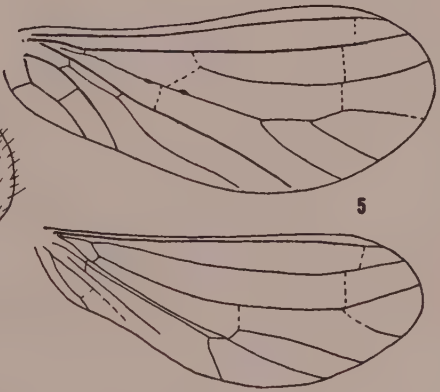

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Carpenter — Spiloconis picticornis

tergite, which I interpret as the tenth; beneath the tenth sternite, which forms the roof of the genital chamber, is a flat plate, presumably a derivative of the ninth sternite; this gonapophysis appears as a hairy, oval disc, when observed from a ventral-posterior direction; internally, it narrows and recurves ventrally. Below this plate is one distinct sclerite, which appears to be the ninth sternite, although it resembles the eighth sternite of the Coniopteryginae in form and could be a derivative of that sclerite.

S. picticornis is most readily recognized by the antennae, the color pattern of which is unlike that of any other species of the genus.

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THE BIOLOGY OF *SPILOCONIS PICTICORNIS* BANKS (NEUROPTERA: CONIOPTERYGIDAE)

M. E. Badgley,[1] C. A. Fleschner,[2] and J. C. Hall[3]

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The dustywing *Spiloconis picticornis* Banks was introduced into California from Taipo, Hong Kong, in 1953 by S. E. Flanders. As it is predaceous on plant feeding mites and scale insects, attempts are now being made to establish it in citrus and avocado groves in southern California. For this reason *S. picticornis* is being reared in large numbers by the Department of Biological Control, University of California Citrus Experiment Station at Riverside. Thousands of individuals of *S. picticornis* have already been released in southern California citrus and avocado groves and many thousands more will be released during the coming season. The following information on the life history and feeding habits of *S. picticornis* was obtained during the process of developing a mass production program for this predator.

Procedure.—These studies were made in a darkened insectary room having a temperature of 80°F. with the relative humidity between 50 and 60 per cent. Adults were kept in 8 dram vials. Each vial was placed over a detached leaf of *Pittosporum Tobira* Ait., the petiole of which was inserted in a ¼ dram vial filled with water and held in place with cotton. The leaves were infested with crawlers of the soft (brown) scale, *Coccus hesperidum* Linn. one to two days before they were to be used. Red scale crawlers, *Aonidiella aurantii* (Mask), were placed on the leaf just prior to insertion into the vial containing the dustywings. Each vial was supplied with a fresh leaf daily.

Egg.—The eggs are irregularly ellipsoidal in outline, approximately 0.53 mm. long and 0.34 mm. wide. They are flat and scale-like. The chorion is strongly reticulate. The reticulations are often stretched and even obliterated during deposition if the egg is not supported. In many instances the eggs follow the contour of the surface upon which they are laid, and are thus distorted from the usual shape. The color of the eggs varies from straw-yellow to pink or pale purple. The straw-yellow colored eggs usually turn pinkish between 12 and 14 days after deposition. The pink or light purple eggs show no change except for the appearance of the eye spots which begin to show up 10 to 12 days after deposition. The length of the egg stage is rather consistent at 16 days.

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[1] Laboratory Technician, Citrus Experiment Station

[2] Assistant Entomologist in the Agricultural Experiment Station

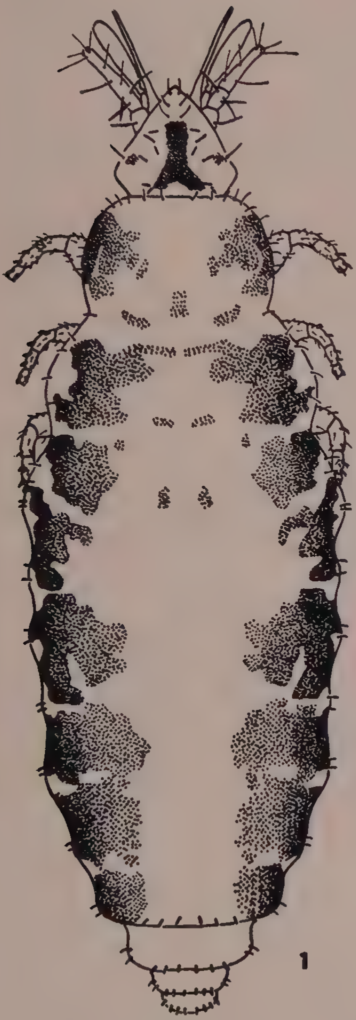
[3] Senior Laboratory Technician, Citrus Experiment Station

Larvae.—As in most Neuroptera the larvae emerge from the egg by means of an egg burster. In this species the egg burster is attached to the hatching membrane which is shed immediately after the egg is broken. While still in the egg the larva is lying on its back with the head curved forward and down between the legs. The egg burster is located on the top of the head and projects upward over the mouthparts. Hatching is facilitated by the movement of the head, which manipulates the egg burster, thus breaking the chorion. The hatching membrane remains attached to the inside of the egg.

The larvae are shortly fusiform, the widest part being the thorax. In color they vary from creamy white to pink. The darker characteristic color pattern is confined to the lateral margins of the body (see fig. 1). The mature larvae are generally more uniformly pinkish-purple with small white markings as well as the dark lateral areas. The gut contents are clearly visible as a central, reddish-brown stripe. The integument of the dorsum of the body and head is very minutely muricate, the points being four and five sided. The venter is nearly smooth. Each abdominal segment bears eight pairs of minute squamiform setae (fig. 2) in addition to two pairs of simple setae;

EXPLANATION OF PLATE 8

Figure 1. Mature fourth instar larva of *S. picticornis*. Figure 2. Enlarged drawing of a dorsal squamiform setae. Figure 3. Exarate pupa of *S. picticornis* showing the attached last larval molt skin.



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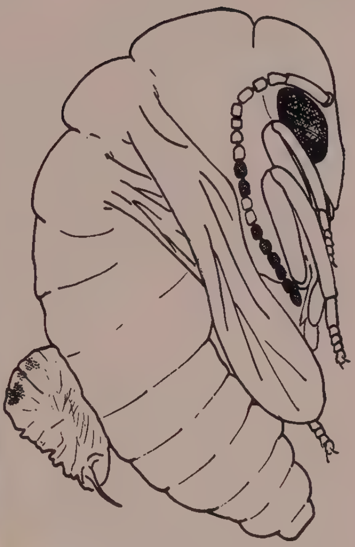

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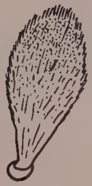

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Badgley, Fleschner, and Hall — Spiloconis picticornis laterally there are two pairs of squamiform setae; ventrally there are four pairs of simple setae on each segment.

The thoracic segment bears eight to ten pairs of dorsal squamiform setae. The head bears six pairs of squamiform setae and four pairs of serrated setae. The antennae are three-segmented and sparsely covered with setae of unequal length; three or four of the basal setae are serrated, the others comparatively smooth. The labial palpi are two-segmented, the second segment being much longer than the first and rather fleshy and swollen. The mandibles and maxillae together form a hollow tube through which the food is ingested. When not feeding, the mouth parts are held in a forward projecting position with the two mandibles and maxillae appearing as a single unit.

S. picticornis larvae pass through four instars. This is in contradiction to the findings of Killington (1936) concerning British Neuroptera. Killington found that all British Neuroptera underwent only three larval molts. The first larval molt of *S. picticornis* occurs one to three days after hatching; the second molt four to seven days later; the third molt takes place five to seven days after the second; and the last or fourth molt occurs within five to eight days. The last instar larva moves about freely for from one to seven days. At the end of its feeding period it seeks a place in which to spin a cocoon. From five to eight days are spent in this fourth instar as a prepupa before the final molt to the pupal stage. The larval skin remains attached to the pupa, usually on the back towards the posterior end (fig. 3). In these studies the total elapsed time in the larval state varied from 16 to 32 days.

The larvae have been observed to feed only upon the scale insects of the diaspine and lecanine groups. The preferred stage of the scale appears to be the younger settled scale, although all stages have been attacked from the crawlers to the second instar. The lecanine scales are more easily consumed than the diaspine scales. In the former group the dustywing larva may make only one feeding puncture, this is through the dorsum of the scale; while in the latter group the larva very often is unable to pierce the scale cover and after several attempts will move to the edge of the scale and insert the mandibles between the cover and the substrate.

When ready to pupate the fourth instar larva selects a crevice or crack in which to spin the cocoon. Contrary to the usual occurrence of two envelopes, it has been found that there are three distinct layers which make up the cocoon. The first or outer layer is loose and lace-like and is mostly the framework by which the cocoon is held in place. The second layer is also lace-like but it has a more definite vertical wall-like construction. The third or innermost layer is thick and closely woven. This last layer is the toughest of the three and is appressed to the pupa contained therein. The whole cocoon is irregularly circular, 2.5 mm. to 3 mm. in diameter, and flattened, approximately 0.5 mm. high.

After the cocoon is spun the larva turns on its side and becomes quiescent. This quiescent prepupal period lasts from five to eight days. At the end of this period the larval skin is shed and the exarate pupa is exposed (fig. 3). The pupal stage lasts from eleven to twenty days. When the adult is ready to emerge the pupa cuts an irregular opening in the cocoon and crawls out, leaving the posterior abdominal segments in the cocoon to act as an anchor. Occasionally the pupa will crawl completely out of the cocoon. In this case emergence of the adult is completed with a great deal of difficulty.

Adult.—Upon completion of emergence the adults are grayish in appearance, they remain in this state until the secretion of the wax-like coating completely covers the body and wings. It has been observed that a period as long as 48 hours may elapse before the adult begins to secrete the wax-like covering.

Mating has not been observed to take place prior to three or four days after emergence. This period is presumed to be the length of time required for the ovaries to mature. The pre-oviposition period varies from four to ten days. Oviposition rarely occurs before mating and when it does the eggs are nonviable. An occasional female has been observed to mate more than once after oviposition has commenced but the necessity for repeated impregnation has not been determined. Within one day after mating the female begins depositing eggs. As many as 20 eggs have been obtained from a single female within a twenty-four hour period, but this is an extreme; the average number of eggs laid during this period has been approximately ten.

The females prefer a rough surface, with many depressions or crevices, for oviposition. In many cases the females will not oviposit if they are not provided with a suitable ovipositional substrate. The eggs are laid singly, but quite often large numbers will be found in a favorable location. Most of the oviposition takes place at night, there being little or no activity during the day.

The length of life of the adults provided with an adequate diet varied from 49 to 63 days. The length of life from the time of egg deposition until death of the adult varied from 92 to 131 days; the average being approximately 110 days under insectary conditions.

Hosts.—While the results obtained and the list of species tested as hosts are not complete, they do indicate the type of food required for development and egg production. As mentioned above the larvae were observed to feed only upon the young scale of the diaspine and lecanine groups. The adults have been observed to feed upon the citrus red mite, *Metatetranychus citri* (McG.) and the citrus rust mite, *Phyllocoptruta oleivora* (Ashm.) in addition to the scale insects. In order to promote egg production and also lengthen the life of the adults, honey and water are necessary. As shown in table 1 the diet which proved to be the most sufficient as to length of life consisted of water, honey and scale crawlers. The length of life of dustywing adults which fed on citrus red mites or citrus rust mites, with honey and water added in each case, was similar to that obtained with a diet of scale crawlers, honey and water.

Table 1 shows that when adults of *Spiloconis picticornis* were fed only citrus red mites or scale crawlers the maximum length of life was four days. When fed only honey, water, or citrus rust mites the maximum length of life was six days. When fed rust mites and water the maximum life period was seven days. When water was added to the scale crawler diet the maximum life period was 18 days. When honey was added to the scale crawler diet the maximum life period was thirty-five days. When both honey and water were added to the scale crawler diet the maximum life period was extended to sixty-three days. When both honey and water were added to the mite diet similar results were obtained.

TABLE 1

Number of Days Adults of *Spiloconis picticornis* Lived When Fed Various Foods or Combinations of Foods.

FOOD	Number of Adults Tested	No. of Days for 50% Mortality	No. of Days for 100% Mortality
Scale Crawlers[1]	26	2	4
Red Mites[2]	10	2	4
Honey	10	5	6
Water	36	3	6
Rust Mites[3]	40	2	6
Rust Mites, Water	30	4	7
Scale Crawlers, Water	6	16	18
Scale Crawlers, Honey	30	18	35
Scale Crawlers, Honey, Water	30	45	63

[1] *Aspidiotus hederae* (Vallot)
[2] *Metatetranychus citri* (McG.)
[3] *Phyllocoptruta oleivora* (Ashm.)

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ECOLOGY AND BEHAVIOR OF THE ANT *BELONOPELTA DELETRIX* MANN (HYMENOPTERA: FORMICIDAE)

By Edward O. Wilson
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Belonopelta Mayr is a little-known genus of ponerine ants represented by two species, *B. attenuata* Mayr of Colombia and *B. deletrix* Mann, the latter hitherto recorded from Honduras and Chiapas (Wheeler, 1935; Brown, 1950). It is of more than usual interest because of the aberrant, presumably raptorial modification of the mandibles. To the present time only several specimens have been mentioned in the literature, and nothing has been recorded concerning its biology.

B. deletrix was recently encountered by the present author near the village of Pueblo Nuevo, Veracruz, in the Cosolapa Valley ten miles south of Cosolapa. This record represents a considerable northwestward extension of the range of the genus. The Cosolapa Valley, like most of this part of Mexico, is under heavy cultivation, and the native forest is limited to precarious sanctuaries on the steep slopes of numerous hills and mountains which rise from the valley floor. Pueblo Nuevo is located in the saddle of a pass through one of the lower hill ranges. To the northwest, and across the nearby Cosolapa River, there is a large tract of true rainforest, i.e., a forest in which the trees are several-storied, with a few "emergents" over 100 feet in height, and heavily festooned in the upper reaches by lianas and epiphytes. The upper stratum forms a closed canopy in the undisturbed portions, and herbaceous undergrowth is very sparse. The forest is being continuously high-graded by crude native lumbering methods, and as a result clearings and patches of scrubby second growth occur throughout. The prevalent ant genera in the leaf litter and soil, as indicated by repeated Berlese funnel samples, are *Wasmannia, Solenopsis* (*Diplorhoptrum*), *Pheidole, Prionopelta, Pyramicus, Neo-*

struma, *Rogeria*, *Strumigenys*, *Paratrechina* (*Nylanderia*), *Octostruma*, and *Odontomachus*, approximately in that order. *Apterostigma*, *Apsychomyrmex*, and *Glamyromyrmex* are among the less common but zoogeographically distinctive ground elements. *Wasmannia*, *Azteca*, *Pseudomyrmex*, and *Paracryptocerus* predominate in the arboreal fauna.

B. deletrix was found on two occasions during ten days' collecting in this forest. First, a single worker was discovered in a rotting, but still firm, section of tree branch, two inches in diameter, buried in deep leaf litter between the buttresses of a large tree. It was in a flat, rectangular, preformed cavity which opened to the soil below by a broad gallery. Six eggs, six larvae, and three worker cocoons were also present, but conscientious search in the immediate vicinity failed to reveal other adults. Later, a complete colony, undoubtedly independent of the first, was discovered nesting several hundred yards away in a rotting branch, of the same dimensions as the first and also buried in leaf litter between the buttresses of a large tree. This colony consisted of ten workers, a dealate queen, ten eggs, twenty larvae of various sizes, and eight cocoons. It occupied a small cavity the diameter of a pencil and six inches long in the center of the branch.

A third collection of the species was made to the east of Pueblo Nuevo in what might best be described as "tropical evergreen" forest (see Leopold, 1950). The soil was drier and rockier than in the rainforest, and the trees formed a single, often-broken canopy with few lianas and epiphytes. The ant fauna in general appeared to be little more than a depauperate extension of the rainforest fauna. A colony fragment of *Belonopelta deletrix*, consisting of three workers, four eggs, and several larvae, occupied a pencil-width cavity in a very rotten, crumbling tree branch three to four inches in diameter lying on the ground and partly covered by rather dry leaf litter. The surface soil and leaf litter in the immediate vicinity were collected in bags, sorted through manually, and then processed in Berlese funnels, but no more adults or brood could be found.

From the limited data given above it is evident that *Belonopelta deletrix,* like many other endemic Neotropical species, can live in more than one type of habitat, despite the fact that it is primarily a rainforest dweller. It is of interest also that groups of workers and brood can exist apart from a queen, although there is no way of knowing whether these groups are fragments of a larger colony or independent colonies founded by workers.

The queen of *Belonopelta deletrix* is a normal female (figs. 1, 3), a fact by itself of considerable significance, since Borgmeier (1950) has shown that the queen of the closely related genus *Simopelta* [*S. pergandei* (Forel)] is dichthadiiform. Not only does this add a large morphological difference between the two genera, but it may foreshadow a fundamental difference in behavior; i.e., *Belonopelta* leads a "typical" sedentary life, while *Simopelta* may be nomadic.

The rainforest colony and larger colony fragment were maintained in artificial nests during a month's period for studies on food habits and behavior. In the field, a worker had been found on the undersurface of a limb near the rainforest colony carrying a dead or paralyzed campodeid in its mandibles. In captivity, other campodeids, as well as a single japygid, were quickly captured by the workers and fed to the larvae. Small geophilid centipedes and a single small cicadellid were also accepted and eaten, but a larger lithobiid centipede was discarded after capture, and other larger centipedes were completely avoided. Termites of the genus *Nasutitermes* were generally avoided in the first weeks, at the most stung to death and then abandoned, but later, after a month's confinement and transfer to the United States, the rainforest colony accepted workers of *Reticulitermes*. Beetle larvae and adults, moth larvae, millipedes, and isopods were avoided. The general impression received is that only a few kinds of small arthropods are readily accepted, and of these, the

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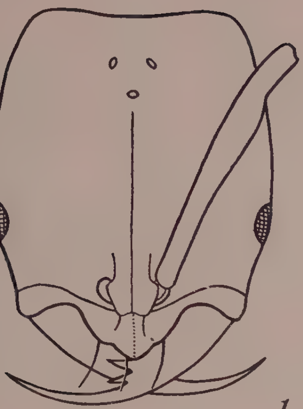
Explanation of Plate 9

Figs. 1-4, *Belonopelta deletrix* Mann. 1, head of queen. 2, head of worker. 3, queen, side view. 4, worker, side view.



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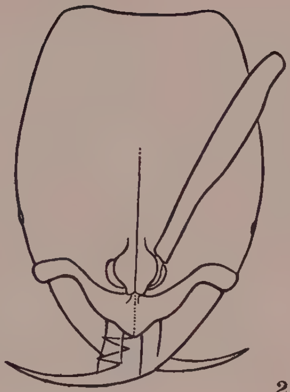

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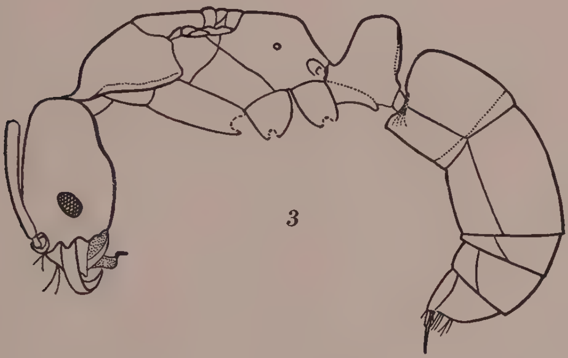

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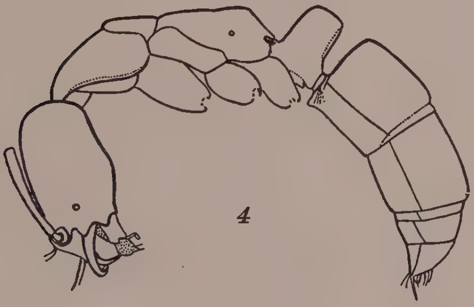

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WILSON — BELONOPELTA DELETRIX

entotrophan families Campodeidae and Japygidae are the preferred prey. In the Pueblo Nuevo forests, campodeids are abundant (many were on the limb housing the rain-forest colony), and they may well form the principal food supply. Honey was ignored by the workers, although available in the artificial nest for at least two weeks.

Despite the rather spectacular development of its mandibles, there does not appear to be anything really unusual about this species' method of catching prey, although it is admitted that the workers were never seen in the act of hunting uninjured entotrophans, the presumed usual prey. When a brood of newly hatched geophilid centipedes was placed in the food chamber, the ants rushed them immediately, seized them with their mandibles, and shook them back and forth with a forward bobbing motion of the head. Only one individual was stung, in addition, before being carried back to the brood. The *Belonopelta,* when hunting or fighting intruders, do not open their mandibles more than is usual for other Ponerini. Also, the mandibles are not handled like traps as in other long-jawed groups such as the Odontomachini and Dacetini, nor does their strike have the stunning effect sometimes observed in these groups. My own interpretation is that their peculiar shape is a special adaptation for pinning entotrophans, which insects are very active and agile, and difficult for most ants to hold and sting.

My *Belonopelta* were generally very timid, in most instances fleeing frantically from arthropods not sought as prey, including the docile *Nasutitermes* workers. Their mandibles crossed one another at rest as shown in figures 1 and 2 and were never opened to threaten intruders. When the workers transported larvae, they cradled them between the concave masticatory borders and avoided using the needle-like apical teeth.

The *Belonopelta* larvae were very active; when disturbed they thrashed violently back and forth in the manner of injured earthworms, but showed no capacity for directed locomotion. Insect prey were fed to them in typical ponerine fashion on their "laps", either entire or cut up into large pieces. The cicadellid mentioned above was placed entire across the laps of two large larvae lying side by side.

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NAME CHANGES IN COCCINELLIDAE. — Among the names proposed by E. Mulsant in his 1850 work on the family Coccinellidae several were preoccupied. Three of these, of interest to students of the neotropical fauna, seem not to have been corrected.

Neopalla new name

Pelina Mulsant, 1850, Species Trimères Sécuripalpes, p. 229, 271; not *Pelina* Curtis, 1838, Guide Brit. Ins., ed. 2, p. 291; not *Pelina* Haliday, 1839, Ann. Mag. Nat. Hist., (1), vol. 3, p. 407.

Palla Mulsant, 1850, loc. cit., p. 273; not *Palla* Hübner, 1819, Verz. bekannt. Schmett., (3), p. 47; not *Palla* Billberg, 1820, Enum. Ins. Mus. Billberg, p. 90.

Type of genus—*Pelina* (*Palla*) *hydropica* Muls.

The genus Pelina was set up by Mulsant for two species, *Pelina lebasi* n. sp. and *P. hydropica* n. sp. For the second of these he proposed a separate subgenus, under the name of *Palla*. Unfortunately, both of these names were preoccupied. The writer has studied the anatomy of both species and does not believe that they should be separated subgenerically. The species, with synonymy, will stand as follows —

Neopalla hydropica (Muls.)
Neopalla lebasi (Muls.)
  Syn. *Neda murilloi* Chpn.

Dargo new name

Oeneis Mulsant, 1850, loc. cit., p. 497, 500; not *Oeneis* Hübner, 1819, Verz. bekannt. Schmett., (4), p. 58.

Type of genus — *Oeneis nigrans* Muls.

Mulsant proposed the genus *Oeneis* for two Brazilian species, *Oeneis obscura* n. sp. and *O. nigrans* n. sp. Crotch, in his Revision of Coccinellidae, 1874, p. 206, selected *O. nigrans* Muls. as genotype and at the same time suppressed the genus as a synonym of *Cryptognatha* Muls. This may have been an unfortunate selection, for a study of the types of the two species may very well show that the two species are not congeneric and that *O. nigrans* Muls. belongs in what is now known as *Delphastus* Casey. If my supposition is correct, *Dargo* will fall as a synonym of *Delphastus* and a new genus will have to be defined for *O. obscura* Muls. and its allies. — EDWARD A. CHAPIN, Museum of Comparative Zoology, Harvard College.

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